1.3 Strange Rocks

Just south of Lethbridge you can find the Bearspaw Rock Formation. This layer of sedimentary rock contains a rare mineral called ammolite, often called *Alberta's Gemstone*. The raw material for this gemstone is a common fossil found in rocks worldwide. What makes this spot rare is that conditions were ideal to preserve these fossils in a way to give them a quality desired by jewellers.

Figure C1.18: The source for ammolite is a fossil called ammonite.

Try This Activity

Take a Wild Guess!

Identify which modern group of animals the ammonite fossil in Figure C1.18 is most closely related to—bighorn sheep, snakes, snails, or squid.

Science Skills

✓ Analyzing and Interpreting

Look up the answer in the Lesson Answers. Were you surprised at the answer? If you made the wrong choice, determine what led you to the wrong interpretation.

Early Explanations

Rocks that resemble living creatures have always made people curious. For centuries, enthusiasts have travelled the countryside amassing large collections of these little treasures. By the seventeenth century, naturalists had begun to classify fossils but were still unsure of their origins. Figure C1.20 shows beautiful drawings of ammonites published by Robert Plot in his 1677 book *The Natural History of Oxfordshire*.

Figure C1.19: The world's largest ammonites measure up to 1 m in diameter!

Until recent times, the belief that these fossils were the remains of once-living creatures was not widely agreed upon. Few people could imagine the process of fossilization in which organic materials turned into stone.

Figure C1.20: Robert Plot drew ammonites.

DID YOU KNOW?

Shark-tooth fossils are so common because all shark species continually shed their teeth. One tiger shark can shed as many as 24 000 teeth in its lifetime!

Basic Questions

In the latter part of the seventeenth century, Nicolas Steno, a trained physician who travelled all over Europe, finally settled in Florence, Italy. While dissecting a large shark's head in Florence, he noticed that the teeth strongly resembled rocks often called *tonguestones*, which he had seen on his travels. This name was given because they looked like dragon tongues. Steno proposed that tonguestones were actually remnants of once-living shark teeth. Although this was a keen observation, he didn't stop there. Instead, he followed up his observation by asking some very basic questions. How can fossilized shark teeth become imbedded in rock that is on land high above sea level? What process caused these teeth to become fossils embedded in solid rock?

As you answer questions 8 and 9, you can retrace the reasoning Steno used to sort out the mystery of how marine fossils could be found on land.

Figure C1.21: Fossilized shark teeth can become embedded in sedimentary rock.

Practice

8. Look at the fossilized shark teeth in Figure C1.21. How could undamaged solid shark's teeth become embedded in sedimentary rock, which is also solid?
9. Hypothesize about which was deposited first—the shark teeth or the strata below the shark teeth. Remember: A good hypothesis includes a reason.

Questions like Practice questions 8 and 9 led Steno to a hypothesis geologists now call the **law of superposition**. It provides a way for geologists to keep track of the order in which rock layers formed. This process is called **relative dating**. Relative dating determines which rock layers are older and which are younger. For instance, you could give a relative date to the clothes in a laundry basket. The clothes at the bottom of the basket must be the oldest because they were deposited first. Clothes on the top must be the youngest because they were deposited last. By using this reasoning, you can determine the relative ages of the clothes (which are older or younger) by examining the basket's strata. In geology, the pattern of rocks in a strata is called the **stratigraphic sequence**.

An exception to the law of superposition can occur when large, underground bodies of magma force hot molten rock to invade cracks found in the sedimentary rock. The invading rock is called an **intrusion**. Since the intrusion was formed by molten rock forcing its way into the cracks of pre-existing rock strata, the intrusion must be younger than the surrounding rock.

- law of superposition: a law stating that higher strata in a sequence of rock layers are younger than lower strata
- relative dating: the process of placing rocks and geological structures in the correct chronological order
- stratigraphic sequence: a sequence of rocks that provides a chronological record of a region's geological history
- intrusion: a body of rock that forms from the invasion of magma into a pre-existing rock formation

Practice

During his travels, Steno observed many outcrops of sedimentary rocks with distinct strata.

10. Determine the relative age of each of the minerals in the stratigraphic sequence in Figure C1.22.

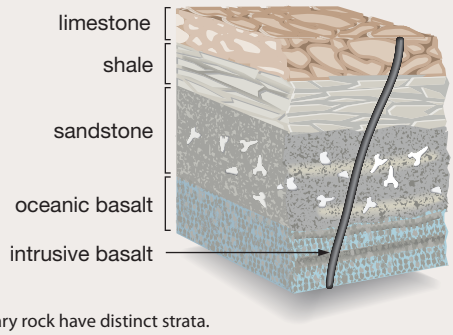
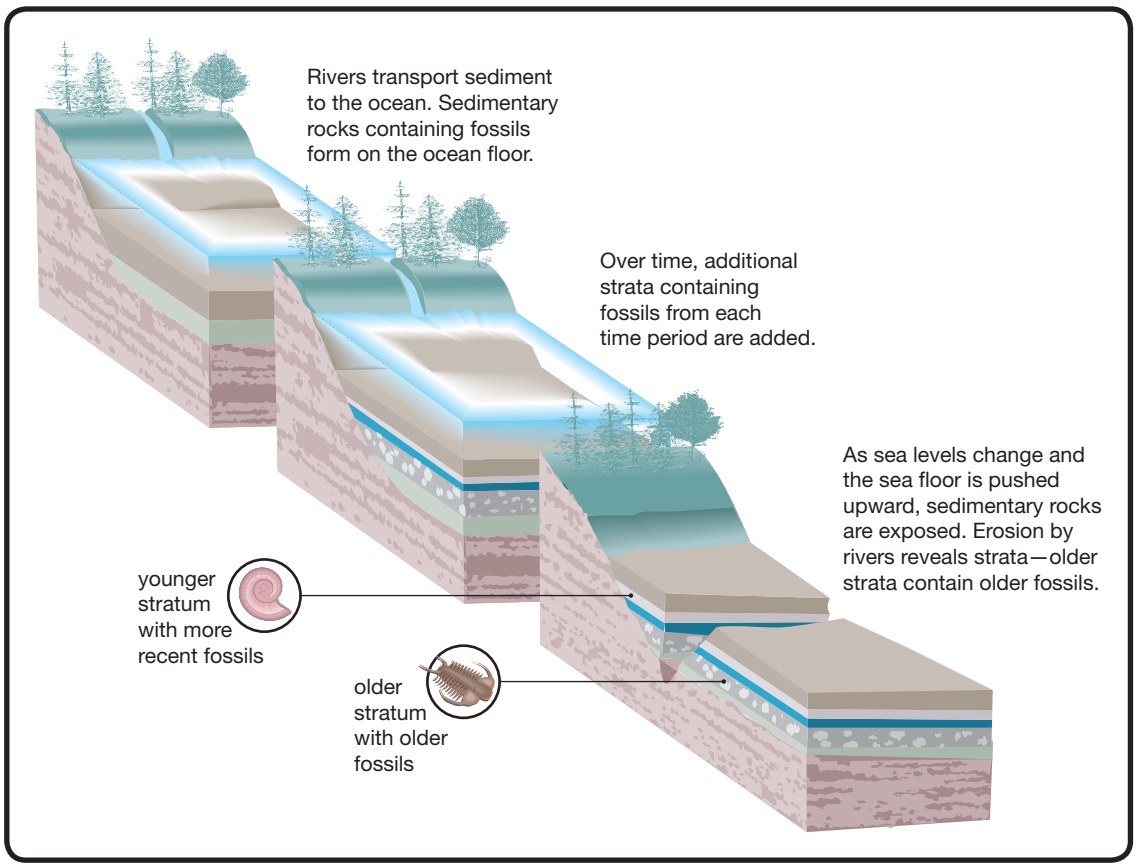


Figure C1.22: Many outcrops of sedimentary rock have distinct strata.

Formation of Sedimentary Rock


Rivers transport sediment to the ocean. Sedimentary rocks containing fossils form on the ocean floor.
Over time, additional strata containing fossils from each time period are added.
As sea levels change and the sea floor is pushed upward, sedimentary rocks are exposed. Erosion by rivers reveals strata—older strata contain older fossils.
younger stratum with more recent fossils
older stratum with older fossils

Utilizing Technology

Pulling It All Together

Science Skills
- ✓ Initiating and Planning
- ✓ Communication and Teamwork

Purpose

Work with other students to develop a concise presentation using either PowerPoint® or a poster to explain the answer to one of Steno's basic questions: "How can fossilized shark teeth become imbedded in rock that is on land high above sea level?"

Procedure

step 1: Plan how many diagrams will be a part of your presentation, what information will be included in each diagram, and what should be communicated in the captions accompanying each diagram.

step 2: Divide the tasks equally among the group members, and complete your first draft of the presentation.

step 3: Locate the handout "Fossilization of Shark Teeth" on the Science 20 Textbook CD. Compare your presentation to the information on this handout. Make any necessary corrections or improvements to your presentation to bring it to second-draft status.

step 4: Share your presentation with at least one other group by asking that group to name three things that you did well, and three things to consider changing for next time.

step 5: View the presentation of at least one other group. Tell that group about three things that they did well, and three things to consider changing for next time.

Evaluation

1. Given the feedback provided by the other group, how would you evaluate your group's presentation?
2. Given the presentation you saw from the other group, what improvements could you add to your own presentation?

Try This Activity

Making a Fossil

Science Skills
- ✓ Performing and Recording

In "Pulling It All Together" you explored the process of how a shark's tooth could become imbedded in rock that is on land high above sea level. In Chapter 2 you will have an opportunity to participate in the next step of examining fossil evidence to determine the characteristics of the original object. To prepare for the next chapter, you will need to make a fossil that can be used by you and your classmates.

Purpose

It is the purpose of this activity to make an impression of an everyday object using plaster of Paris. Only you and your partner should know the identity of the item—this is because your classmates will try to identify it only from the impression it leaves in the plaster of Paris.

Materials

- plaster of Paris
- water
- foam bowl to hold mould
- cooking oil spray (non-stick coating)
- felt-tipped pen with permanent ink
- newspapers or cardboard to collect dust and debris
- small object to embed in plaster (e.g., a toy soldier, bone, or leaf)
- lab aprons

Procedure

step 1: Label the bowl with the name of you and your partner.

step 2: Mix water with the plaster in the bowl or container so that the bowl is about half full.

step 3: Spray the object with cooking oil and place it on top of the plaster. Make sure there are no air bubbles under the object. Spray a coating of cooking oil on top of the plaster and the object, and then add another plaster layer.

step 4: Set the object aside until you are ready to start Chapter 2.

Rocks Keep a Record of Events

You can use the principle of relative dating to put clothes in a laundry basket in the correct chronological order, but you can't use it to determine how many hours or days ago an individual item was put in the basket. In the same way, by having evidence that younger layers of sediment are deposited on top of older layers, geologists can assign relative dates to fossils and events present in the layers. The main limitation of relative dating is that it does not reveal the **absolute age** of events or fossils.

absolute age: the number of years that have elapsed since an event occurred

Practice

Use Figure C1.23 to answer questions 11 and 12.

Figure C1.23: This road in Hawaii had to be closed because lava from an active volcano spilled over it.

11. Determine the relative age of the lava and the road.
12. Explain why you cannot precisely determine the absolute age of the road or the lava on the road.

Smith's Observations

Using Steno's law of superposition, early geologists had a fundamental tool needed to rank strata—and the fossils and events they contained—in chronological order. What was lacking was a way to construct a unified history of Earth's crust for entire regions or maybe even the entire planet. It took more than 100 years before an English surveyor supplied the key discovery.

William Smith (1769–1839) travelled all over England as a surveyor. One of his biggest jobs was acting as a surveyor for a canal project. Surveyors were important because diggers had to know what types of rocks to expect. Smith carefully examined the rock strata at many dig sites. His careful observations led him to develop a remarkable hypothesis. Smith noticed that certain distinctive fossils kept re-appearing at each surveyed location.

Further, these distinctive fossils always appeared in the same order within the layers of rock at each location.

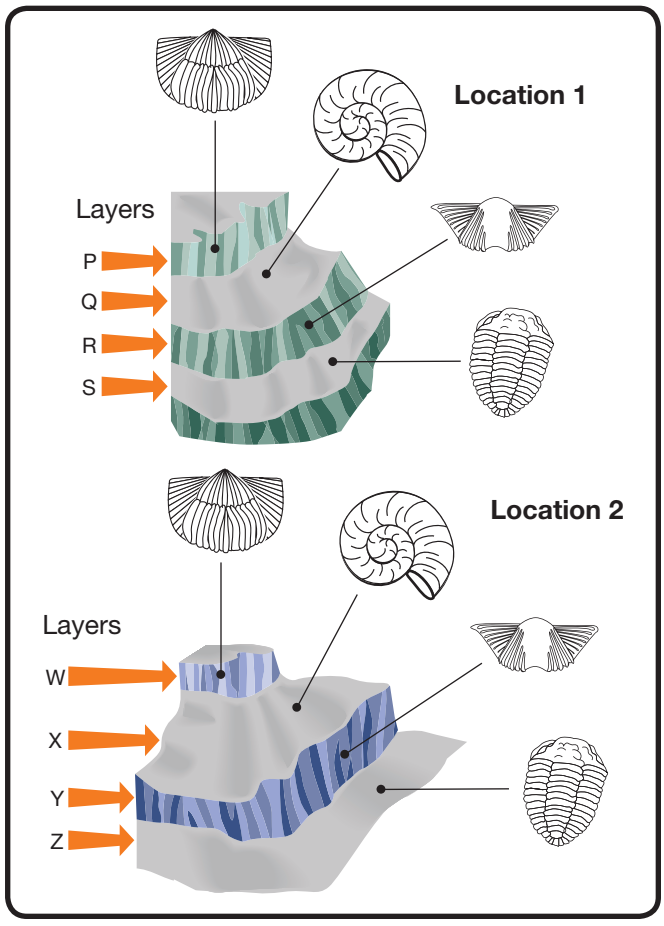


Figure C1.24: The same pattern of fossils is shown in two different locations.

If a distinctive fossil existed only for a limited period of time, then rocks containing that fossil must correspond closely in age with other rocks that contain that same fossil. These distinctive fossils are like an index; they establish a common time of origin for widely dispersed rock layers. That's why these fossils are called **index fossils**.

index fossil: a fossil used to determine the relative age of a layer in a stratigraphic sequence or to match stratigraphic sequences from different locations

Practice

13. Examine Figure C1.24 closely.
    a. Determine the oldest layers of rock at Locations 1 and 2.
    b. Determine the youngest layers of rock at Locations 1 and 2.
    c. Conclude which layer in Location 1 contains rock of roughly the same age as the rock in layer X of Location 2.

A Big Puzzle

Over many years, Smith travelled around England observing and recording stratigraphic sequences and matching them together by using a variety of index fossils. In 1815, Smith published his greatest achievement as a scientist—the first complete geological map of England. Due to his relatively humble beginnings and education, Smith's contribution was largely ignored when it was published. It would take a new generation of geologists to finally recognize his profound impact. Smith finally received a major award for his work at age 62. This was 16 years after the original publication of his geological map.

Investigation

Matching Rock Strata from Different Locations

Problem

Can stratigraphic sequences from different locations be matched by using index fossils to form one larger sequence?

Materials (for each group of students)

- scissors
- handout called "Eight Fossil Cards" from the Science 20 Textbook CD
- handout called "Assembled Stratigraphic Sequence" from the Science 20 Textbook CD

Procedure (for each group of students)

step 1: Use the scissors to cut out the eight fossil cards from the handout.

step 2: Place the fossil card with the letter M in the lower left-hand corner of your workspace. This represents the oldest rock layer, so it is on the bottom.

step 3: Find a rock layer on a fossil card that contains at least one of the fossils you found in the oldest rock layer. This rock layer is younger, as indicated by the presence of a new fossil species. Place this rock layer above the oldest rock layer.

step 4: Repeat the process outlined in step 3 to select a fossil card to be the third rock layer.

step 5: Check your work. If a fossil is present in layer 1, it should not disappear from layer 2 and then re-appear in layer 3. Since extinction is forever, once a fossil disappears from the fossil record it does not return. If necessary, re-adjust the fossil cards you chose for layers 2 and 3.

step 6: Repeat the previous three steps for each of the remaining fossil cards. When you are finished you should have the rock layers assembled into a stratigraphic sequence.

Analysis and Interpretation

1. Use the letters on the cards to list the sequence of cards from youngest to oldest.
2. Conclude if the youngest sequence should be at the top or the bottom. Identify which scientific law you must apply to answer this question.
3. Identify what type of dating is used in this investigation.
4. Evaluate the main limitation of this kind of dating.

Science Skills

- ✓ Initiating and Planning
- ✓ Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communication and Teamwork

Reporting Your Results

5. Use the handout titled "Assembled Stratigraphic Sequence" to summarize your findings. Draw arrows to represent the part of the fossil record in which the organism lived. Remember, it should be one continuous arrow. If there are breaks in the arrow, you have assembled the sequence incorrectly.
6. In paragraph form, write a short report that answers the following questions:
   - How did your group assemble the fossil record?
   - Which species make the best index fossils?
   - Why should these species make good index fossils?
7. Explain how index fossils might be used to estimate the age of newly discovered fossils.

The Grand Record

A useful index fossil appears only briefly in the geological record, has a wide geographical distribution, and is easily recognizable. During the nineteenth century, geologists used index fossils to assemble a generalized relative time scale for all of Earth. The entire sequence is not preserved in any one place, so sequences from all over the world were used to assemble an ideal stratigraphic column that generalizes Earth's entire history. Today, the idealized sequence is called the Geological Time Scale (shown in Figure C1.25). The Geological Time Scale is divided into four major eras: Precambrian, Paleozoic, Mesozoic, and Cenozoic. A massive disappearance of fossils and an unexplained appearance of new fossils mark the boundary between each era. Each era is broken down into smaller divisions called periods. In some cases, periods are broken down into epochs. To this day, geologists continue to debate and refine details of this time scale.

Geological Time Scale

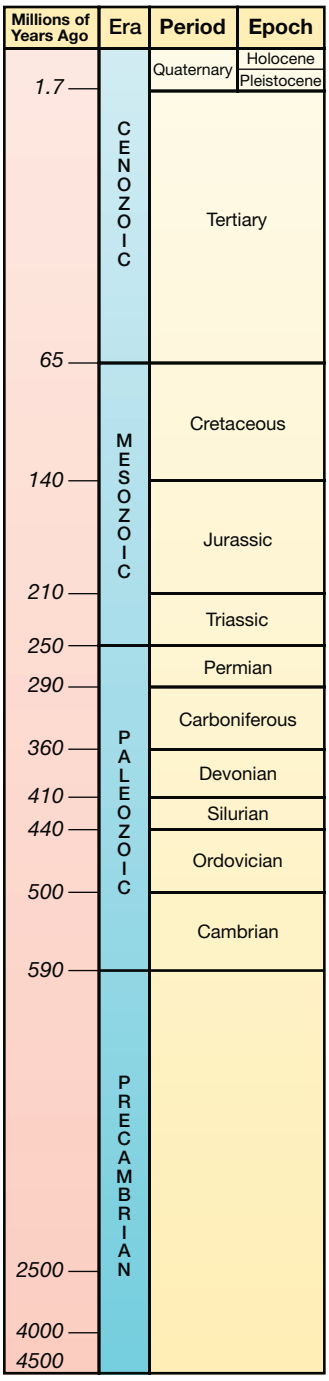


Figure C1.25: You can also find the Geological Time Scale on page 557, and it is also a handout.

An Idealized Rock Column for Alberta

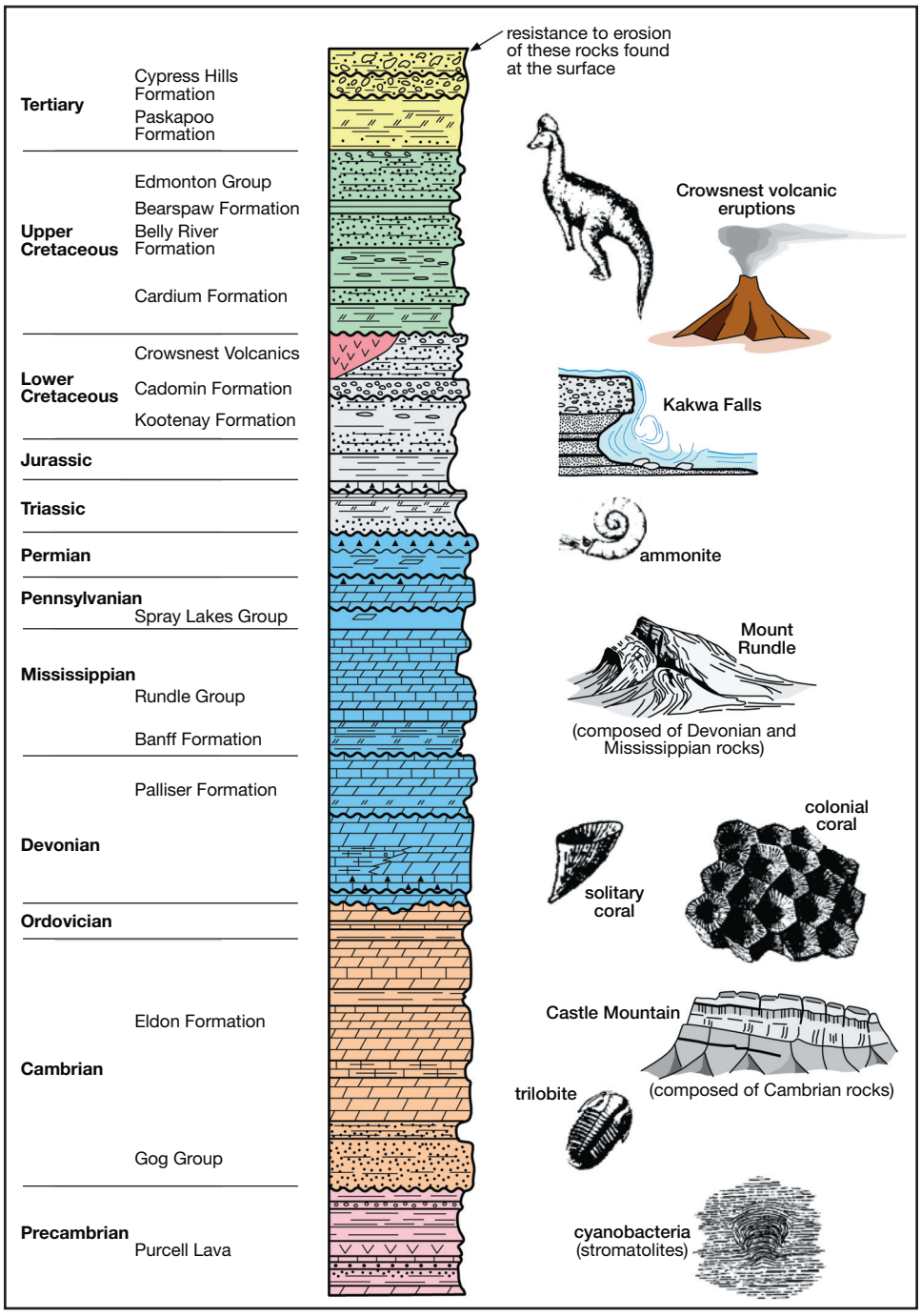


Figure C1.26: This idealized rock column for Alberta does not completely exist in any one place. It is pieced together from outcroppings all over the province.

Try This Activity

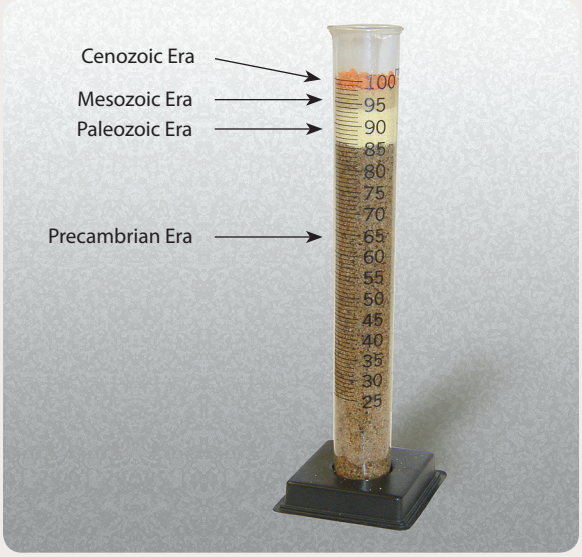
Hourglass of Time

The Geological Time Scale is almost never drawn with proper dimensions. This is simply for convenience. Although the Precambrian Era comprises nearly 90% of the time scale, fossil evidence is scarce. Conversely, much more is known about the Cenozoic Era because it is the most recent one. In this activity, each colour of sand represents one of the four eras and the volume of sand approximates the amount of time for that era.

Sketch a diagram of the graduated cylinder filled with sand. Label each era, and include the time it started and the time it ended.

Science Skills

✓ Performing and Recording



1.3 Summary

Throughout history, fossils have made people curious. However, it wasn't until the seventeenth century that a physician named Nicolas Steno was able to figure out that fossils are the remains of once-living species. He also proposed one of the fundamental laws of geology—the law of superposition. This law states that a particular rock layer is younger than the layers below it. This provided geologists with a way to order events. It was still a challenge to compare strata from one location to strata at another place. This problem was solved by William Smith's discovery of index fossils. Work with index fossils eventually led to the creation of a stratigraphic column for all of Earth, called the Geological Time Scale. Geologists use this scale to summarize Earth's history according to fossil evidence. Its largest division is eras, which are broken down into periods.

1.3 Questions

Knowledge

1. Summarize the contributions of Nicolas Steno and William Smith to the field of geology.
2. Identify the qualities of a useful index fossil.
3. List the four eras of the Geological Time Scale.

Applying Concepts

4. **a.** Calculate the percentage of Earth's history for each era. Round all answers to the nearest percent.
   b. Using the percentages calculated, sketch a pie chart of the four eras.
5. Use your calculations from 4.a. and 4.b. to determine whether the Geological Time Scale shown in Figure C1.25 is drawn to scale.
6. Describe the criteria geologists use to divide the Geological Time Scale into eras.
7. Identify the name for the subdivisions of an era.
8. Identify which period is more recent—the Triassic or the Permian.
9. Which epoch you are living in?
10. The last ice age was called the Pleistocene Ice Age. Identify the period in which it appeared.